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LEARNING FROM THE PAST: A CONCEPTUAL MODEL OF INDEPENDENT TYPOLOGY FORMATION IN THE DESIGN STUDIO

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ABSTRACT: Students of architecture are predominantly taught in the design studio environment, through active projects, encouraging independent learning. Architectural precedent is often seen a key driver in generating design solutions and analysing appropriateness. Typologies, understood as systems for categorising precedents, and the subsequent formation of types, can be used to extract relevant design information for use in the design studio. This study examines how novice designers may use typologies to construct critical frameworks for design. By interpreting design through the Critical Method, as a process of conjecture and analysis, typologies may help to frame problems, generate design solutions and assess suitability.

A pilot study with novice designers was undertaken to assess the impact of pre-determined typologies on the design process. Initial findings suggest architectural types may help students in the conjectural phase of design, however, pre-determined categorisation may restrict individual interpretation and limit analysis. This paper describes initial findings and the developing conceptual model for interpreting built precedent and incorporating it into design studio teaching.

Keywords –Typology, precedent, design studio, independent learning, Critical Method

1. INTRODUCTION

1.1 Precedent and design

The use of precedent and case based reasoning in the design process has been well documented in both architecture (Akin, 2002; Anay, 2006; Eilouti, 2009; Heylighen, Neuckermans, Casaer, & Dewulf, 2007; Murbarak, 2004; Tice, 1993; Waldman, 1982) and in broader fields of design (Defazio, 2008; Kolodner, 1992; Maher & Gómez de Silva Garza, 1997; Schmitt, 1993).

A meta-analytic review by Sio, Kotovsky, and Cagan (2015) assessed a broad range of studies and considered the impact of timing, common-ness and number of examples presented on design solutions. The study considered design a problem solving activity where individuals ‘search’ for solutions through a defined problem space. The study found that presenting fewer, unfamiliar examples encouraged students to explore the problem space and generate ideas of higher quality and novelty. Their findings also suggest that quality, novelty and degree of copying marginally increase when examples are issued before the problem solving phase, whilst variety decreased.

These results are echoed by Eilouti (2009) and Casakin (2011) who observed the uptake of precedent based knowledge is more successful in the pre-design phase and can be used to provide clarity to the original problem. Conversely, Akin (2002) found that precedents were more often used to corroborate existing designs.

A common characteristic of the literature is the tendency to assume design as a problem-solving activity, considering it a solution to a question. This allows the effect of ideation to be considered in relation to the stated problem and solutions assessed on their ability to 'solve' it. This view of design is founded in the work of Herbert Simon (1969, 1977) considering it a process of problem analysis followed by solution synthesis (Bamford, 2002).

1.2 Design Problems

Commonly in architecture, problems are not fully defined at the outset. More often than not the aspired outcome is ill determined, changeable and only becomes apparent throughout the design process. Moreover, architectural projects are subject to conflicting values of various stakeholders, not least the architect themselves, which make its specific identification an impossibility. Dorst (2011) claims that in design problems, the end value is known at the outset but as H. W. Rittel (1972) has argued, in planning problems "*there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing*". Such problems could be considered *wicked problems* (Bazjanac, 1974; Buchanan, 1992; Churchman, 1967; H. W. J. Rittel & Webber, 1973; Rowe, 1987).

Understanding design as a purely problem solving activity is challenging when faced with wicked problems. Maher and Poon (1996) propose a model of co-evolution whereby the problem space takes on definition simultaneously with the solution space. Dorst and Cross (2001) describe the creative act of design as happening at the moment when the problem and solution spaces are linked forming *design situations* (Dorst, 2011; Hatchuel, 2001; Maher & Poon, 1996).

1.3 The Critical Method

The Critical Method (CM) is a model of design which describes the co-evolution of design problem and design solution. Hillier, Musgrove, and O'Sullivan (1972) suggests a conjecture/analysis model, analogous to the critical rationalism developed by Karl Popper (1963). The process is developed further in Brawne's description of CM (2003) and can be summarised as:

$$PD^1 \rightarrow TS^1 \rightarrow DD^1 \rightarrow PD^2 \rightarrow \dots$$

PD^1 is the initial problem definition, TS^1 trial solutions and DD^1 design development (Brawne, 2003; Wright, 2011). In the context of architectural design, it may be necessary to elaborate on this model further, considering PD^1 as the *project* definition, differentiating architectural design from a purely problem solving activity.

2. CRITICAL FRAMEWORKS

2.1 Constructing critical frameworks

In CM the project takes on definition as the design solution is generated and through an iterative process the designer *frames* the project. Work by Goffman (1974) made the notion of framing an influential one in the social sciences (Paton & Dorst, 2011). Frames may be defined cognitively by the designer's cognitive map, or as the product of '*social symbolic structures*' (p. 574). Framing in the context of design has been described by Schön (1984) whereby through training and experience, tacit knowledge is used to shape project spaces (1985, p.24).

Paton and Dorst (2011) recognise the inherent subjectivities embedded in frames. Client and architect will each frame the design situation; the client's frame is shaped by their aspirations; the architect's frame by their professional knowledge and experience. In this scenario, the client's frame is influenced by the architect's *primary-generators*, a set of conceptual ideas, in the briefing process (Darke, 1979). The design space is re-framed, simplifying the task whilst evoking possible problem outcomes (Paton & Dorst, 2011).

Framing in architecture could be understood as a hierarchical construct in which the upper levels are formed by primary generators whilst the lower levels are increasingly less defined and slowly develop shape through reflective action (Minsky, 1974). The messy nature of the architectural process means the frame is constantly evolving, and elements maybe be defined, redefined and discarded. Experienced designers may have more sophisticated primary generators and are able to more rapidly shape a greater proportion of the problem space. Conversely, novice designers may lack the experience to adequately shape and reshape problem frames.

2.2 A typological frame

As Brawne (2003) has suggested, the notion of historical precedent is paramount in CM and provides the closest approximation to the Popperian epistemology. Architectural knowledge resides in built forms, in precedents and existing urban fabric and typology offers a means of interpreting this knowledge.

The complexity of tacit knowledge and architectural problems, mean that in reality, reframing situations will not occur from a single identifiable source. Whilst there may be prevailing or overarching conceptual trends, inherent subjectivities of the designer and the multi-faceted nature of designing necessitate a range of techniques. This may pose a problem for less experienced designers as Wright (2011) notes: '*The process by which designs are generated appears ill-defined and quasi- mysterious*' (p.114). Consciously attempting to construct problem frames using precedent may provide a stronger conceptual and theoretical basis for design (Hillier et al., 1972, p.1).

Developing the notion of primary generators and interpreting design as a processes of *generator - conjecture - analysis* (Darke, 1979, p.38) the study described examines how primary generators may be constructed typologically. A conscious attempt to bypass the inherent generators of the novice designer is attempted by asking whether design can be instigated without the presence of a

design problem, but rather only a typological stimulus.

Crowe (2014) studied the effect of students engaging in typological studies of historic buildings based on contemporary design problems. He found this lead to an expedient method of producing design solutions that could accommodate new, but not unprecedented conditions whilst allowing the transmission of shared cultural values.

2.3 Defining Typology

The various historical interpretations of architectural type provide a rich vein of discourse. Before its emergence in architectural parlance, the writings of Vitruvius (2015) and Alberti (1966) provide a notion of type as a model to be emulated. Moneo (1978) describes the development of the concept of type from Enlightenment reductionism reflected in the work of Quatremère de Quincy (Lavin, 1992) and J.N.L. Durand (Madrazo, 1994) to modernist prototypical architecture and the neo-rationalist notion of type as a purveyor of meaning (Rossi, Eisenman, Ghirardo, & Ockman, 1982).

For the purposes of the study, a typology is defined as any means of classification of architectural precedent into 'types' based on shared characteristics. In this sense, it is not absolute (as in Quatremère de Quincy for instance) and there is no one defined method of classification (Von Meiss, 2013). Typologies maybe spatial, tectonic, functional, ideological or any other means of defining groups of characteristics manifest in architecture. For the purposes of the study, typology is understood spatially and precedents are categorised through shared spatial characteristics.

3. CONJECTURING WITH TYPE

3.1 Aims of the study

When working with novice designers, primary generators may be abstract, unsophisticated and naïve. Can novice designers be presented with pre-defined typological primary generators in order to construct the problem space?

The study described asks whether the project space can be formed through exposure to types before the introduction of a brief or set of requirements and what effect this has on the creative process in novice designers. Can solutions be generated before knowledge of the problem?

The study has the following stated objectives:

1. To assess the effect of visual typology exposure before the knowledge of written requirements on the design product.
2. To assess the effect of visual typology exposure before the knowledge of written requirements from a learner perspective
3. To assess the effect of exposure to different visual typological representations in the design process.

3.2 Methodology

First year architecture students at the University of Bath after six months of study were used as subjects for the experiment. The experiment took place within a controlled environment. Students worked around tables in allocated groups related to the particular briefs they were presented with. This avoided the use of possible additional stimuli in the design process. Whilst talking and discussion was not prohibited, the students generally worked in silence, partly due to the time pressures of the task.

Students were given two A3 sheets, each marked with a space for a plan, section, elevation and 3D view. A 1m grid at 1:50 was lightly drawn on the scale drawings to enable sketches to be drawn to scale without the requirement of scale rulers. It was made clear that the design did not have to conform to the grid.

The study was split into two halves. The first exercise was twenty-five minutes long, in which the students were presented with an initial stimulus and asked, to respond to it in plan, section, elevation and a three dimensional sketch on the sheet provided. The second part of the exercise involved the introduction of a second stimulus in which the students were asked to consider as additional requirements to the initial stimulus and modify or adapt their original design in response, also twenty-five minutes long. It was made clear there was no requirement to complete all the drawings and they should achieve as much as they could in the time available. It was made clear it was not assessed and anonymous.

3.3 Independent Variables

Students were presented with a single design problem and a number of additional briefs providing typological examples.

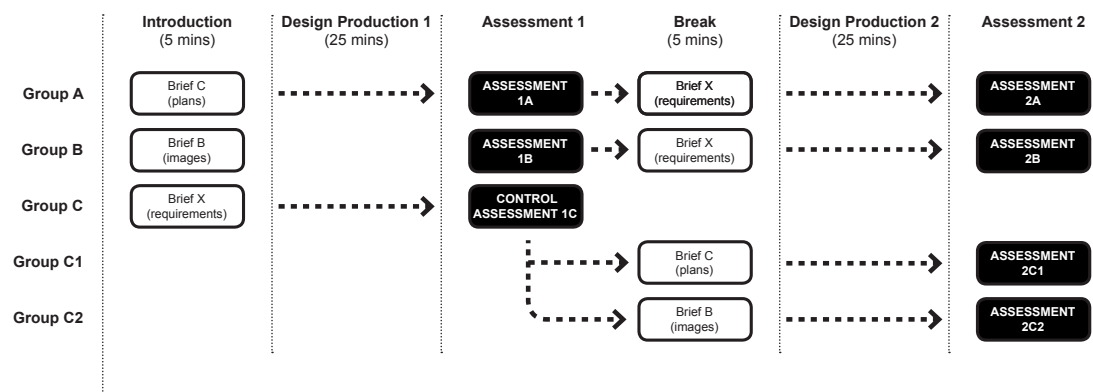
- Brief X was a written brief that described the functional requirements of the proposal. It gave a short description of the client (in this case a philosopher who requires a 'space to think'), lists the spaces required, details of the site and the necessity to form an introverted environment with a 'garden room'. The brief was deliberately designed to imply the creation of a courtyard however this term was not used to avoid the associated connotations.
- Brief A was deliberately blank.
- Brief B consisted of three images of courtyards, from different historical periods and geographic regions (a renaissance European monastic courtyard, a Japanese temple and an image of a contemporary courtyard by Louis Kahn).
- Brief C was a series of plans of different courtyards at different scales including monasteries, houses and temples.

The different briefs and the order in which they were presented acted as the independent variables in the task. Within the reasonable bounds of the experiment, all other variables were kept the same. The students were told briefs B and C represented images of the sorts of spaces that their client liked and wanted to create.

59 students were tested and presented with the briefs in different orders over two design exercises (table 1).

- Group A were exposed to Brief C (plans) for the initial design exercise and Brief X (written requirements) for the second part of the study.
- Group B were exposed to Brief B (images) for the initial design exercise and Brief X (written requirements) for the second part of the study.
- Group C were exposed to Brief X (written requirements) for the initial design exercise. This acted as a control.
- Group C1 were exposed to Brief X (written requirements) for the initial design exercise (as above) and Brief C (plans) for the second part of the study.
- Group C2 were exposed to Brief X (written requirements) for the initial design exercise (as above) and Brief B (images) for the second part of the study.

Table 1. Experiment Structure



3.4 Assessment metrics

Based on ideation assessment criteria outlined by Shah, Smith, and Vargas-Hernandez (2003) and Nelson, Wilson, Rosen, and Yen (2009) four metrics were assessed.

3.4.1 Novelty

Novelty assesses how unusual each idea is to an expected norm. Given the explicit nature of the design brief, and the direct relationship between the typological examples and the spatial requirements, a typical response can be generated. Each requirement was considered and possible responses were assigned a novelty score *a priori* (Table 2). All attributes were weighted equally thus the novelty score could be calculated from:

$$M_1 = \sum_{j=1}^m S_{1j} / m$$

Where M_1 is the overall novelty score for an idea with m attributes, and S_{1j} is the novelty score of each attribute (modified from Shah et al., 2003). The mean

novelty and standard deviation for each group was calculated out of providing a novelty score out of 10.

Table 2. Novelty Score Assignment

Attribute	Novelty Sub score (S_1)		
	3	7	10
Relationship to external space	Central garden room	Walled garden	Other
Spatial arrangement	Courtyard	Centralised	Other
Separation from	Internalised	Walled boundary	Other

3.4.2 Variety

Variety measures the extent to which the solution space is explored (Shah et al., 2003). As each student is asked to develop and present only one idea, this metric represents variation within the group rather than an individual level. The method involves creating a genealogy tree for each set of ideas. The variety is indicated by the number of branches on the tree, with each level on the tree assigned a weighting as one moves down the tree. Developing Nelson et al. (2009) the first branch is defined by general spatial strategies, the second by spatial and site relationships, the third by formal and volumetric manifestation and the fourth by opening strategies, detail and ornament. This was developed from the nature of the brief set and the designs presented. Any number of functional and aspirational values could be assigned to the branches of the tree however this was felt adequate given the scale and sophistication of the explored solution space.

It is important to note that in generating design solutions, some students progressed further than others. As such these designs do not permeate further down the design tree to the detail stage. It is conceivable that designs may begin from the base of the genealogy tree (e.g. from developing a specific detail or space). Where these are developed but not expanded to a fully developed design, they are assigned a variety score based on how far they rise up the tree.

The variety is calculated by assigning value to the different stages of the genealogy tree where the first stage is worth 10 points, the second, 5, the third 2 and the final stage 1 point. From the refined metrics presented by Nelson et al. (2009) the following can be used to calculate a variety amongst a group set.

$$V = \sum_{j=1}^m f_j \left(S_1(b_1 - 1) + \sum_{k=2}^4 S_k \sum_{l=1}^{b_k-1} d_l / (N - 1) \right)$$

S is the score of each level of the tree (S_1 is the first level), d_l is the number of differentiations at node l . The formula calculates the average level at which differentiation occurs (Nelson et al., 2009).

3.4.3 Quality

The absence of formal design information, due to the rapid nature of the task, means designs were not developed beyond conceptual stage. This allows an estimation of quality (Shah et al., 2003) scored out of 10 for each design and then the mean score for the group taken. Quality was assessed against the requirements in the brief where 5 represented rudimentary fulfillment of the brief and marks awarded for refinement and sophistication.

3.4.4 Similarity

The similarity of designs between the two design phases was ranked out of 10, where 10 represented almost completely identical designs. To achieve 10, 100% of design characteristics were shared and 9 represented 90% of common characteristics.

3.4.5 Student feedback

The limited scope of the design task, the restricted time and the controlled nature of the output meant that assessment of the task could be limited to the requirements stated in the brief and the structured output allowed the measurement of a number of other metrics. Students' perceived efficacy of the different briefs was also ascertained.

Students were asked to:

- to evaluate their own success at performing the task
- whether the briefs limited their creative process, whether the additional briefs helped their problem solving ability
- whether they feel they would have been able to perform better having received the briefs in a different order
- whether they would have performed better without additional information
- whether the overall task enhanced their ability to generate design solutions

These questions were presented in an anonymous survey, linked to each project, and students were asked to strongly agree or disagree, agree or disagree or if they were unsure to a number of statements.

4. RESULTS

4.1 Novelty

Table 3 shows the mean novelty scores for each set of groups, with the standard deviation in parenthesis.

Table 3. Novelty Scores

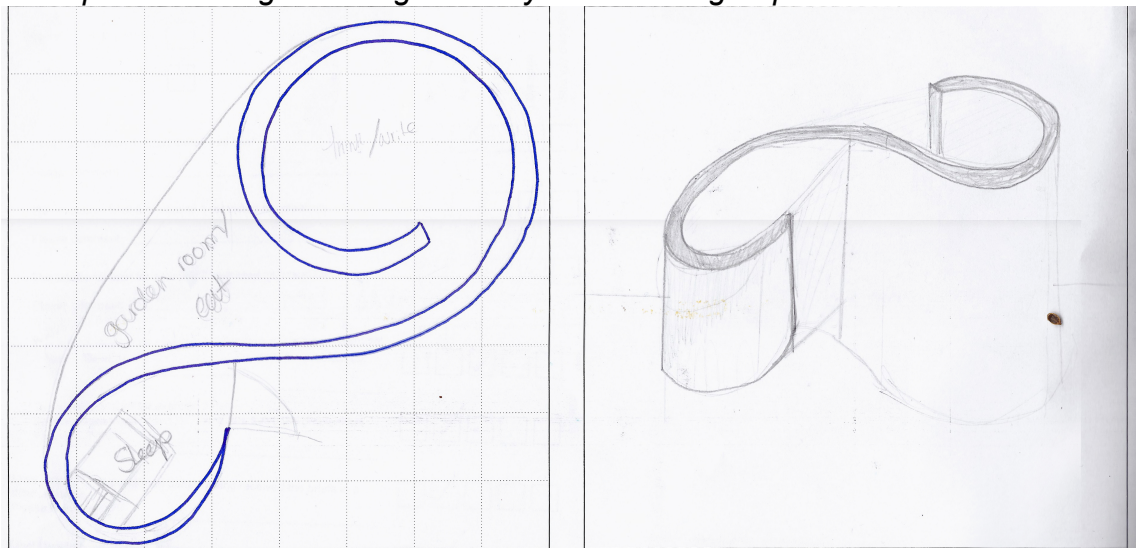
	Group A (SD)	Group B (SD)	Group C (SD)	
			C1	C2
Assessment 1 1st Brief	Plans	Images	Written	
	4.95 (2.89)	6.86 (2.58)	5.71 (1.86)	

Assessment 2 2nd Brief	Written	Written	Plans	Images
	4.86 (2.64)	6.76 (2.31)	5.24 (1.29)	6.19 (2.30)
Individual novelty change	-0.18 (4.35)	0.14 (2.98)	0.14 (3.73)	0.71 (3.53)

Students initially produced the more novel solutions when presented with typological examples in the form of images ($m = 6.86$, $p = 2.58$) compared to the control condition ($m = 5.71$, $p = 1.86$). Being presented with plans initially yielded the lowest novelty score ($m = 4.95$, $p = 2.89$) and results were most similar to the expected outcome.

The greatest increase in novelty between the design exercises occurred when the control group were presented with typological images following the initial design exercise ($m = +0.71$, $p = 3.53$). However, greater absolute novelty was observed in Group B the second task, when images then the written brief were presented ($m = 6.76$, $p = 2.31$). Group A (plans then written brief) decreased in novelty.

Example 1. A design with high novelty score from group B



4.2 Variety

Table 4 shows the variety scores for each set of groups. As this metric is assessed as a group and normalized, individual designs are not comparable to this overall score, and there is no mean or standard deviation.

Table 4. Variety Scores

	Group A (SD)	Group B (SD)	Group C (SD)	
			C1	C2
Assessment 1 1st Brief	Plans	Images	Written	
	3.90	4.26	5.54	
Assessment 2	Written	Written	Plans	Images

2nd Brief	3.81	4.22	5.83	8.33
Group variety change	-0.10	-0.04	0.29	2.79

The greatest variety in the initial exercise was seen when students were issued written briefs whilst being exposed to plans yielded less the least variation. This trend continued into the second exercise with Group C exhibiting marked increases in variety whilst additional written briefs yielded no further variation amongst the group.

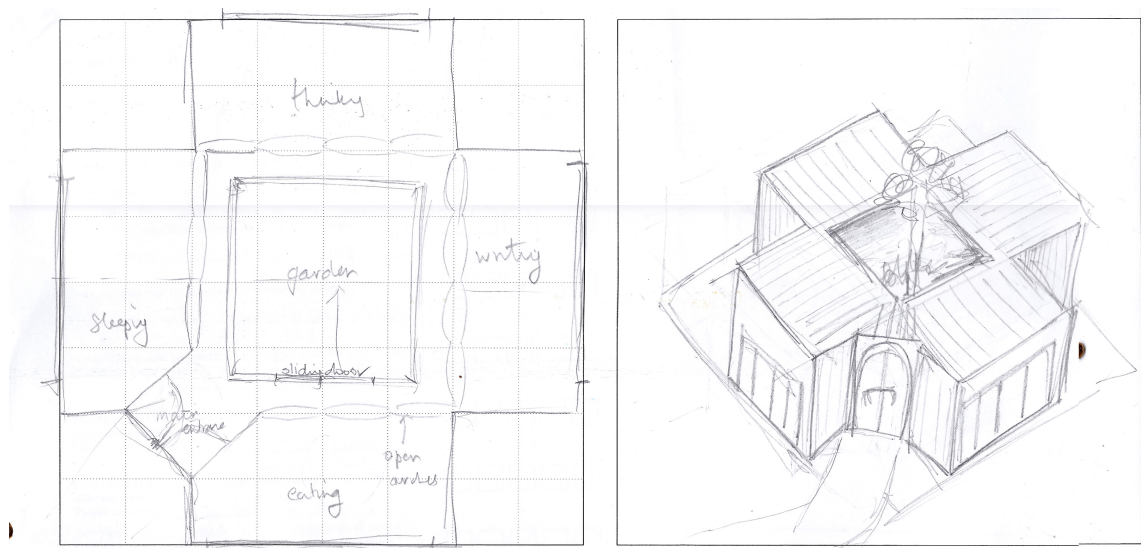
4.3 Quality

Table 5. Quality Scores

	Group A (SD)	Group B (SD)	Group C (SD)	
			C1	C2
Assessment 1 1st Brief	Plans	Images	Written	
	5.18 (1.82)	3.42 (1.47)	5.79 (1.85)	
Assessment 2 2nd Brief	Written	Written	Plans	Images
	5.18 (1.87)	5.33 (1.66)	5.34 (1.29)	6.19 (2.3)
Individual quality change	0.73 (1.88)	1.92 (1.82)	-0.14 (1.21)	0.00 (1.41)

In the initial design exercise Groups A and C produced significantly higher quality solutions than group B who were only presented with images ($m = 3.42$, $p = 1.47$). Improvement in quality was observed in both Groups A and B (those that were presented with the written brief after the initial design task) Neither of the control groups increased the quality of their designs in the second design task however the mean of this metric was higher in both groups C1 and C2 ($m = 5.34$ and $m = 6.19$) compared to both groups A and B.

Example 2. A design with low novelty and high quality scores from group C



4.4 Similarity

Table 6. Similarity Scores

Group A (SD)	Group B (SD)	Group C (SD)	
		C1	C2
Plans then written	Images then written	Written then plans	Written then images
6.77 (1.85)	7.46 (1.74)	6.71 (1.50)	5.71 (3.04)

The greatest similarity of designs in assessments 1 and 2 was observed in group B, who were issued images followed by written requirements ($m = 7.46$). Conversely, being exposed to images following a written brief (Group C2) yielded the least similarity between assessments.

4.5 Student Feedback

There was very little variation in student feedback between groups. All groups found the visual briefs improved their creativity and helped develop design solutions. The greatest variety was in whether students would have preferred to receive the briefs simultaneously.

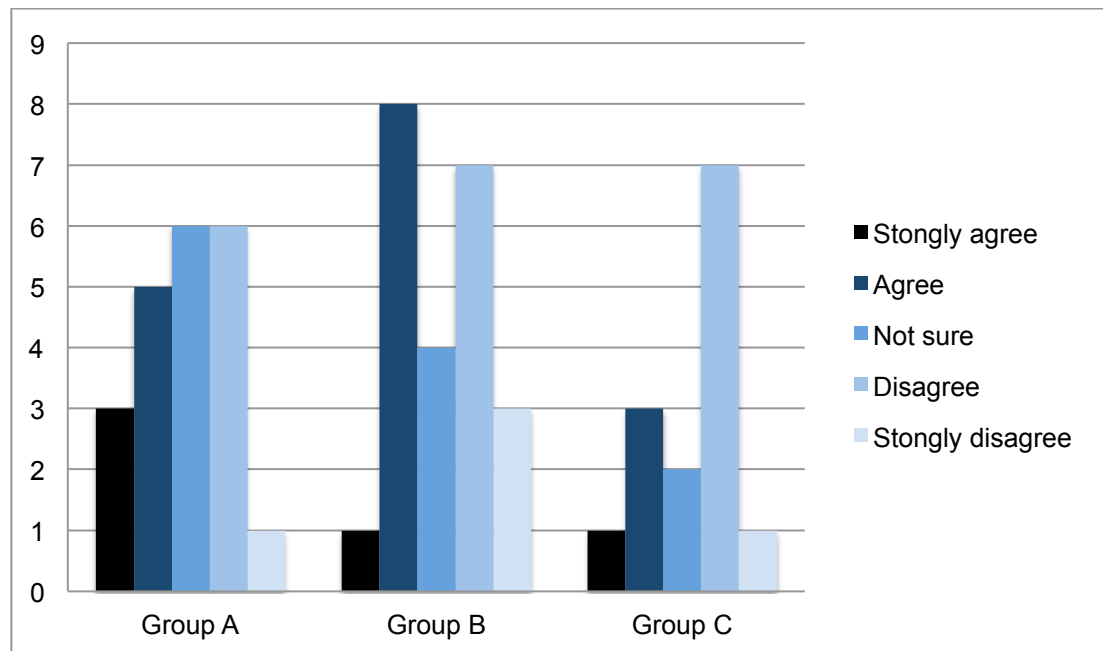


Figure 1. Results of questionnaire when asked : I feel I would have performed better having received both briefs simultaneously.

Whilst groups A and B were mostly undecided, group C generally disagreed with this statement, preferring to receive the briefs in order given (written brief then visual brief).

Groups A and C tended to disagree with the statement that they would have performed better receiving the briefs in a different order however the group exposed to images initially would generally have preferred to receive this later in the design process.

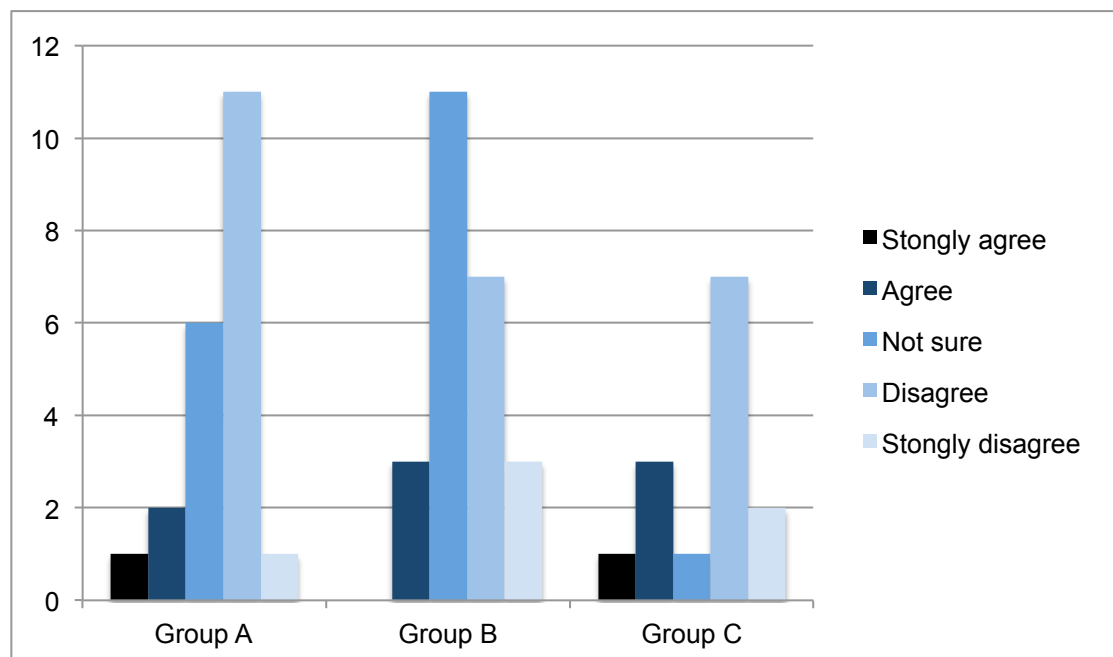


Figure 2. Results of questionnaire when asked : I feel I would have performed better having received the briefs in a different order.

5. CONCLUSION

5.1 Discussion

The study suggests there was limited effectiveness of a typological pre-design phase, and the control group generally produced higher quality and more novel designs. Despite this there were a number of conclusions that can be drawn.

The effect of exposing students to visual briefs in the form of plans before written requirements was effective at limiting the novelty and variety of solutions. This suggests students found plan information more helpful at shaping the project space to generate typical spatial arrangements than being presented with imagery or written requirements. These findings are reflected in the work of Casakin (2011) and Eilouti (2009). Moreover, the quality of designs was comparable to the control group (group C) in the first exercise suggesting the appropriate selection of typologies can be as informative as explicitly stated requirements at generating adequate solutions. Exposure to example plans later in the design process (group C1) lead to a reduction in quality suggesting early incorporation may be of value.

Initial exposure to images lead to more novel solutions yet there was not an increase in variety when compared to the control group reflecting the findings of Sio et al. (2015). Students tended to extract surface characteristics and not to observe common structural or spatial types, often generating unexpected yet significantly lower quality solutions than the control group. Often, visual characteristics were borrowed from only one or two of the precedent images, indicating a lack of analysis or realization of common themes.

When students conducted pre-design based on a set of images a marked improvement in the quality of their designs was observed, compared to the other groups. Both the groups that conducted a pre-design phase without a written brief exhibited greater similarity between assessments when compared to the control group. This implies students were able to adapt existing typological concepts to apply to new situations more readily than existing project spaces could be mapped onto new typologies. Whilst this might imply a degree of design fixation, the improvement in quality suggests this was not disadvantageous. Improvement in quality was particularly significant in when students were exposed to typological images first suggesting significant advantages of individual interpretation in the pre-design phase.

Being presented first with a written brief followed by a visual one yielded greater mean group novelty, variety and quality in the second assessment yet on an individual level this increase was less marked. This was particularly noticeable in the quality scores where individuals, on average retained almost identical levels of quality. Incremental changes in quality were offset by large drops in quality in a number of participants, suggesting exposure to briefs in this order may confuse the design space in some students.

From a student perspective, the results suggest a preference to receive visual stimulus in the form of images later in the design process, after written requirements have been issued, and diagrammatic stimulus (in the form of plans) before the written brief. A number of students cited the value of typologies to narrow their focus and help creativity through the imposition of restraints.

5.2 Limitations

The study was conducted as an experiment outside of the design studio and projects. Decontextualising the experiment from the natural conditions of the design studio meant the work was limited in scope and representativeness. The contrived nature of the study avoided the complexity of the design process and was not a true reflection of how the studio operates. Nevertheless, it allowed isolation of the experimental variables, the establishment of a control group and a tailoring of the work to suit the experiment.

5.3 Conclusions

Assessment of ideation metrics has previously taken place mostly in the fields of engineering and industrial design where solutions can be assessed against desired outcomes. In these contexts, novelty and variety are valued as providing fresh insights into the problem solving process. As suggested, the nature of architectural design is such that concrete outcomes are not always obvious and designers are called upon to construct their own design situations to frame the project. Conducting a pre-design phase, with the absence of written requirements, proved effective at limiting the scope of the project space and lack of novelty or variation could be considered advantageous. This may be of particular value in CM where the symbiotic relationship of conjecture and analysis requires the formation of clearly defined analytical structures.

The results suggest that students found it easier to map written requirements to developed visual ideas rather than the other way around providing a case for the introduction of typology in a pre design phase. The diminished quality of designs that occurred when this was done could be accounted for by a lack of understanding or depth of analysis of the examples presented. This was particularly apparent in students who were initially presented with images of typologies.

In the context of CM, the value of novelty and group variation are not explicit. Whilst the generation of multiple and various ideas is advantageous at exploring the project space, without developing critical frameworks, the ability to analyse their success is compromised. Exposure to preselected types appeared to enable rudimentary critical frameworks to be constructed however this was severely limited by a lack of analysis.

The study suggests independent student typology generation is essential to enable understanding of how precedent may directly apply to a design situation and cannot be bypassed by predefined and imposed typologies.

5.4 Further Study

Further study needs to be undertaken to help students develop a deeper understanding of typology at the pre-design phase. This could be through self selecting or formation of typologies related to a broad and non-specific written brief. It is hypothesized that lack of understanding was the primary barrier in the successful integration of typology and that its effectiveness as an ideation tool.

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